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Compressive Strength of Concrete with Partial Replacement of Cement by Fly Ash

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ABSTRACT
During last few decades several researches have been carried out on blending of the fly ash in Ordinary pozzolanic cement (OPC). In the present study fly ash is used in Portland pozzolanic material (PPC) concrete as partial replacement of PPC. Fly ash is a pozzolanic material which produces calcium-silicate-hydrate (C-S-H) when reacts with free lime present in cement during the hydration. This paper present the experimental result carried out to determine workability and compressive strength of concrete at different replacement of PPC. M-25 grade of concrete (1:1.53:3) at w/c of 0.42 was designed as per IS-10262-2009. Result shows that PPC can be replaced up to 20% by fly ash without compromising compressive strength of concrete.

KEYWORDS: *Cement, Fly ash, Concrete, IS 10262-2009, Compressive Strength of concrete*

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1. INTRODUCTION

In the view of global warming efforts are on to reduce the emission of CO2 to the environment. Cement Industry is major in contributor in the emission of CO2 as well as using up high levels of energy resources in the production of cement. By replacing cement with a material of pozzolanic characteristic, such as the fly ash, the cement and the concrete industry together can meet the growing demand in the construction industry as well as help in reducing the environmental pollution

1.1. Fly ash:- In India coal is a major source of fuel for production of electricity. Fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

Class F fly ash: The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO).

Class C fly ash: Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time.

Utilization of flyash:-

The ways of fly ash utilization include (approximately in order of decreasing importance):

1. Concrete production, as a substitute material for Portland cement andsand
2. Embankments and other structural fills (usually for roadconstruction)
3. Grout and Flowable fill production
4. Waste stabilization andsolidification
5. Cement clinkers production - (as a substitute material forclay)
6. Mine reclamation
7. Stabilization of soft soils
8. Road sub base construction
9. As Aggregate substitute material (e.g. for brick production)
10. Mineral filler in asphalt cconcrete
11. Agricultural uses: soil amendment, fertilizer, cattle feeders, soil stabilization instock feed yards, and agricultural stakes
12. Loose application on rivers to melt ice
13. Loose application on roads and parking lots for ice control.

AIM & OBEJCTIVE:-

AIM:- To determine workability and compressive strength of concrete at different replacement of Fly ash partially replaced with PPC .

OBJECTIVES:-

The objective of study was to understand the effect of physical and chemical properties of fly ash on strength development and hydration of mortars and cement pastes.

- To study the fly ash material used and application in construction industry.
- Comparative review of the technology used through smart material and check its economic feasibility.
- To compare the fly ash material on various factors w.r.t. conventional material.

LITERATURE REVIEW:-

Chatterjee, (2011) reported that about 50 % of fly ash generated is utilized with present efforts. He also reported that, one may achieve up to 70% replacement of cement with fly ash when high strength cement and very high reactive fly ash is used along with the sulphonated naphthalene formaldehyde superplasticizer. He reported improvement in fly ash property could be achieved by grinding and getting particles in sub microcrystalline range.

Bhanumathidas, &Kalidas, (2002) with their research on Indian fly ashes reported that the increase in ground fineness by 52% could increase the strength by 13%. Whereas, with the increase in native fineness by 64% the strength was reported to increase by 77%. Looking in to the results it was proposed that no considerable improvement of reactivity could be achieved on grinding a coarse fly ash. Authors also uphold that the study on lime reactivity strength had more relevance when fly ash is used in association with lime but preferred pozzolanic activity index in case of blending with cement.

Subramaniam, Gromotka, Shah, Obla& Hill, (2005) investigated the influence of ultrafine fly ash on the early age property development, shrinkage and shrinkage cracking potential of concrete. In addition, the performance of ultrafine fly ash as cement replacement was compared with that of silica fume. The mechanisms responsible for an increase of the early age stress due to restrained shrinkage were assessed; free shrinkage and elastic modulus were measured from an early age. In addition, the materials resistance to tensile fracture and increase in strength were also determined as function of age. Comparing all the test results authors indicated the benefits of using ultrafine fly ash in reducing shrinkage strains and decreasing the potential for restrained shrinkage cracking.

MATERIAL USED:-

Cement:- The cement used was Ambuja Cement (OPC-43 GRADE), because of its fine nature, good particle size distribution, optimal phase composition, imparts the properties of higher strength to the structures and the chemical and physical lab properties of Ambuja Cement (OPC-43 Grade) surpasses the properties of OPC 43 Grade as defined in IS:12269–1987.

Table 4.1.1 Typical constituents of Portland clinker plus gypsum

Clinker	CCN	Mass %
Tricalcium silicate $(CaO)_3 \cdot SiO_2$	C3S	45–75%
Dicalcium silicate $(CaO)_2 \cdot SiO_2$	C2S	7–32%
Tricalcium aluminate $(CaO)_3 \cdot Al_2O_3$	C3A	0–13%
Tetra calcium alumino ferrite $(CaO)_4 \cdot Al_2O_3 \cdot Fe_2O_3$	C4AF	0–18%
Gypsum $CaSO_4 \cdot 2\,H_2O$	CSH2	2–10%

FLY ASH:-

Fly ash, also known as Pulverized Fuel Ash (PFA), is an industrial ash created when coal is burned to create electrical power. Fly ash, which is largely made up of silicon dioxide and calcium oxide, can be used as a substitute for Portland cement, or as a supplement to it.

CHEMICAL COMPOSITION OF FLY ASH:-

Component	Bituminous	Sub bituminous	Lignite
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

COARSE AGGREGATES

Coarse aggregates are the major ingredients of concrete. They provide a rigid skeleton structure for concrete and act as economical space filters. Sizes of aggregates used were 20mm, crushed and angular aggregates.

FINE AGGREGATE

The river sand and crushed sand was used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand was washed and screened, to eliminate deleterious material and over size particle. Fine aggregate passing through 600 micron sieve was used.

WATER

It is the most important and least expensive ingredient of concrete. It distributes the cement evenly. It lubricates the mix. The quantity of water is the most important parameter and is controlled by the w/c ratio.

MERHODOLOGY:-

1. SLUM CONE TEST:

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work.

Equipments Required for Concrete Slump Test: Mould for slump test, non porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end.

2. COMPRESSIVE STRENGTH TEST

Compressive strength of concrete:

Test for compressive strength is carried out either on cube or cylinder. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load

should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

3. CURING

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

4. MIX DESIGN

The Concrete Mix was prepared as per the procedure given in IS 10262:2009 for the optimal dosage selection of fly ash powder from both places in the concrete mix ranging from (20% TO 35%) are prepared and compared with plain M20 Cement Concrete Cubes (1:1.67:3.33)

Data Required for Concrete Mix Design

1. Concrete Mix Design Stipulation
A. Characteristiccompressivestrengthrequiredinthefieldat28daysgradedesignation— M20
B. Nominal maximum size of aggregate — 20mm
C. Shape of CA —Angular
D. Degree of workability required at site — 80 mm (slump)
E. Degree of quality control available at site — As per IS:456
F. Type of exposure the structure will be subjected to (as defined in IS: 456) —Mild
G. Type of cement: OPC 43Grade

2. Test data of material (to be determined in the laboratory)
A. Specific gravity of cement —3.15
B. Specific gravity of FA —2.70
C. Specific gravity of CA —2.56
D. Fine aggregates confirm to Zone II of IS –383

Procedure for Concrete Mix Design of M20 Grade Concrete at 0%replacement

Step 1 — Determination of Target Strength
ftarget = fck + 1.65 x S
= 20 + 1.65 x 4.0
= 26.6 N/mm2

Where, S = standard deviation in N/mm2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:- From Table 5 of IS 456, (page no 20)
Maximum water-cement ratio for Mild exposure condition = 0.5

Step 3 — Selection of Water Content From Table 2 of IS 10262- 2009,
Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)
Estimated water content for 90mm slump = 186+4.8/100x186 =194.92 liters

Step 4 — Selection of Cement Content
Water-cement ratio = 0.5
Corrected water content = 194.92 kg /m3
Cement content =194.92/0.50= 389.84 Kg/m3 From table no. 5 of IS code 456:2000
Minimum cement content for mild condition = 300 Kg/m3
389.84>300 kg/m3 Hence ok.

Step 5: Estimation of Coarse Aggregate proportion:-
From Table 3 of IS 10262-2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = ZoneII
And For w/c = 0.5
Volume of coarse aggregate per unit volume of total aggregate = 0.62
For pumpable concrete this value should be reduced by 10%
Therefore, volume of coarse aggregate= 0.62x0.9 = 0.558
Volume of fine aggregate content =1-0.558= 0.442

Step 6: Estimation of the mix ingredients
The mix calculations per unit volume of concrete shall be as follows
A. Volume of concrete =1m3
B. Volume of cement = (mass of cement/ specific gravity of cement) x1/1000 = (389.84/3.15)x1/1000 = 0.123 m3
C. Volume of water = (mass of water/specific gravity of water) x1/1000 = (194.92/1) x 1/1000 = 0.194 m3
D. Volume of all in aggregate =a- (b+c) =1- (0.123+0.194) = 0.683 m3
E. Mass of coarse aggregate = d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.683 x 0.558 x 2.56 x 1000 = 975.65 Kg
F. Mass of fine aggregate = d x volume of fine aggregate x specific gravityof fine aggregate x1000 = 0.683 x 2.70 x 0.442 x 1000 = 815.09 Kg

Step 7: Mix proportion for trial
A. Cement = 389.84Kg/m3
B. Fine aggregate = 815.09Kg/m3
C. Coarse aggregate = 975.65Kg/m3
D. Water Cement Ratio =0.50
E. Water = 194.92Kg/m37.

Procedure for Concrete Mix Design of M20 Grade Concrete

Replacement of cement in concrete by fly ash 20%.
Step 1 — Determination of Target Strength
ftarget = fck + 1.65 x S = 20 + 1.65 x 4.0 = 26.6 N/mm2
Where, S = standard deviation in N/mm2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:- From Table 5 of IS 456, (page no 20)
Maximum water-cement ratio for Mild exposure condition = 0.5

Step 3 — Selection of Water Content From Table 2 of IS 10262- 2009,
Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)
Estimated water content for 90mm slump = 186+4.8/100x186 =194.92 liters

Step 4 — Selection of Cement Content
Water-cement ratio = 0.5
Corrected water content = 194.92 kg /m3
Cement content =194.92/0.50= 389.84 Kg/m3 From table no. 5 of IS code 456:2000
Minimum cement content for mild condition = 300 Kg/m3
389.84>300 kg/m3 Hence ok.
Cement Content= 70%
Fly ash content= 20% by weight of cement = 20/100 x 389.84 = 77.96 Kg/m3
Lime content = 10 % by weight of cement =10/100 x 389.84 = 38.98 Kg/m3

Step 5: Estimation of Coarse Aggregate proportion:- From Table 3 of IS 10262-2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = Zone II

And For w/c = 0.5 Volume of coarse aggregate per unit volume of total aggregate = 0.62
For pumpable concrete this value should be reduced by 10%
Therefore,
volume of coarse aggregate= 0.62x0.9 = 0.558
Volume of fine aggregate content =1-0.558= 0.442

Step 6: Estimation of the mix ingredients
The mix calculations per unit volume of concrete shall be as follows

A. Volume of concrete =1m3
B. Volume of cement = (mass of cement/ specific gravity of cement) x1/1000 = (389.84/3.15)x1/1000 = 0.123 m3
C. Volume of water = (mass of water/specific gravity of water) x1/1000 = (194.92/1) x 1/1000 = 0.194 m3 d) Volume of all in aggregate =a- (b+c) =1- (0.123+0.194) = 0.683 m3
D. Mass of coarse aggregate = d x volume of coarse aggregate x specific gravityof coarse aggregate x 1000 = 0.683 x 0.558 x 2.56 x 1000 = 975.65 Kg
E. Mass of fine aggregate = d x volume of fine aggregate x specific gravityof fine aggregate x 1000 = 0.683 x 2.70 x 0.442 x 1000 = 815.09 Kg

Step 7: Mix proportion for trial

A. Cement = 272.89Kg/m3
B. Fly ash = 77.96Kg/m3
C. Lime = 38.98Kg/m3
D. Fine aggregate = 815.09Kg/m3
E. Coarse aggregate = 975.65Kg/m3
F. Water Cement Ratio =0.50
G. Water = 194.92Kg/m3

Replacement of cement in concrete by fly ash 25% .
Step 1 — Determination of Target Strength
ftarget = fck + 1.65 x S = 20 + 1.65 x 4.0 = 26.6 N/mm2
Where, S = standard deviation in N/mm2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:- From Table 5 of IS 456, (page no 20)
Maximum water-cement ratio for Mild exposure condition = 0.5

Step 3 — Selection of Water Content From Table 2 of IS 10262- 2009,
Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)
Estimated water content for 90mm slump = 186+4.8/100x186 = 194.92 liters

Step 4 — Selection of Cement Content
Water-cement ratio = 0.5
Corrected water content = 194.92 kg /m3
Cement content =194.92/0.50= 389.84 Kg/m3 From table no. 5 of IS code 456:2000
Minimum cement content for mild condition = 300 Kg/m3
389.84>300 kg/m3 Hence ok.
Cement Content= 65%
Fly ash content= 25% by
weight of cement = 25/100 x 389.84 = 97.46 Kg/m3
Lime content = 10 % by
weight of cement =10/100 x 389.84 = 38.98 Kg/m3

Step 5: Estimation of Coarse Aggregate proportion:- From Table 3 of IS 10262-2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = Zone II And For w/c = 0.5

Volume of coarse aggregate per unit volume of total aggregate = 0.62
For pumpable concrete this value should be reduced by 10%
Therefore, volume of coarse aggregate= 0.62x0.9 = 0.558
Volume of fine aggregate content =1-0.558= 0.442

Step 6: Estimation of the mix ingredients
The mix calculations per unit volume of concrete shall be as follows

A. Volume of concrete =1m3
B. Volume of cement = (mass of cement/ specific gravity of cement) x1/1000 = (389.84/3.15)x1/1000 = 0.123 m3
C. Volume of water = (mass of water/specific gravity of water) x1/1000 = (194.92/1) x 1/1000 = 0.194 m3 d) Volume of all in aggregate =a- (b+c) =1- (0.123+0.194) = 0.683 m3
D. Mass of coarse aggregate = d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.683 x 0.558 x 2.56 x 1000 = 975.65 Kg
E. Mass of fine aggregate = d x volume of fine aggregate x specific gravity of fine aggregate x1000 = 0.683 x 2.70 x 0.442 x 1000 = 815.09 Kg

Step 7: Mix proportion for trial

A. Cement = 253.40Kg/m3
B. Fly ash = 97.46Kg/m3
C. Lime = 38.98Kg/m3
D. Fine aggregate = 815.09Kg/m3
E. Coarse aggregate = 975.65Kg/m3
F. Water Cement Ratio =0.50
G. Water = 194.92Kg/m3

Replacement of cement in concrete by fly ash 30%
Step 1 — Determination of Target Strength
ftarget = fck + 1.65 x S = 20 + 1.65 x 4.0 = 26.6 N/mm2
Where, S = standard deviation in N/mm2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:- From Table 5 of IS 456, (page no 20)
Maximum water-cement ratio for Mild exposure condition = 0.5

Step 3 — Selection of Water Content From Table 2 of IS 10262- 2009,
Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)
Estimated water content for 90mm slump = 186+4.8/100x186 =194.92 liters

Step 4 — Selection of Cement Content
Water-cement ratio = 0.5
Corrected water content = 194.92 kg /m3
Cement content =194.92/0.50= 389.84 Kg/m3 From table no. 5 of IS code 456:2000
Minimum cement content for mild condition = 300 Kg/m3
389.84>300 kg/m3 Hence ok.
Cement Content= 60%
Fly ash content= 30% by
weight of cement = 30/100 x 389.84 = 116.95 Kg/m3
Lime content = 10 % by
weight of cement = 10/100 x 389.84 = 38.98 Kg/m3

Step 5: Estimation of Coarse Aggregate proportion:- From Table 3 of IS 10262-2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = Zone II And
For w/c = 0.5

Volume of coarse aggregate per unit volume of total aggregate = 0.62
For pumpable concrete this value should be reduced by 10%
Therefore, volume of coarse aggregate= 0.62x0.9 = 0.558
Volume of fine aggregate content =1-0.558= 0.442

Step 6: Estimation of the mix ingredients
The mix calculations per unit volume of concrete shall be as follows

A. Volume of concrete =1m3
B. Volume of cement = (mass of cement/ specific gravity of cement) x1/1000 = (389.84/3.15)x1/1000 = 0.123 m3
C. Volume of water = (mass of water/specific gravity of water) x1/1000 = (194.92/1) x 1/1000 = 0.194 m3 d) Volume of all in aggregate =a- (b+c) =1- (0.123+0.194) = 0.683 m3
D. Mass of coarse aggregate = d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.683 x 0.558 x 2.56 x 1000 = 975.65 Kg
E. Mass of fine aggregate = d x volume of fine aggregate x specific gravity of fine aggregate x1000 = 0.683 x 2.70 x 0.442 x 1000 = 815.09 Kg

Step 7: Mix proportion for trial

A. Cement = 233.90Kg/m3
B. Fly ash = 116.95Kg/m3
C. Fine aggregate = 815.09Kg/m3
D. Coarse aggregate = 975.65Kg/m3
E. Water Cement Ratio =0.50
F. Water = 194.92Kg/m3

Replacement of cement in concrete by fly ash 35%

Step 1 — Determination of Target Strength
ftarget = fck + 1.65 x S = 20 + 1.65 x 4.0 = 26.6 N/mm2
Where, S = standard deviation in N/mm2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:- From Table 5 of IS 456, (page no 20)
Maximum water-cement ratio for Mild exposure condition = 0.5

Step 3 — Selection of Water Content From Table 2 of IS 10262- 2009,
Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)
Estimated water content for 90mm slump = 186+4.8/100x186 =194.92 liters

Step 4 — Selection of Cement Content
Water-cement ratio = 0.5
Corrected water content = 194.92 kg /m3
Cement content =194.92/0.50= 389.84 Kg/m3 From table no. 5 of IS code 456:2000
Minimum cement content for mild condition = 300 Kg/m3
389.84>300 kg/m3 Hence ok.
Cement Content= 55%
Fly ash content= 35% by
weight of cement = 35/100 x 389.84 = 136.45 Kg/m3
Lime content = 10 % by
weight of cement = 10/100 x 389.84 = 38.98 Kg/m3

Step 5: Estimation of Coarse Aggregate proportion:- From Table 3 of IS 10262-2009,
For Nominal maximum size of aggregate = 20 mm,
Zone of fine aggregate = Zone II And For w/c = 0.5
Volume of coarse aggregate per unit volume of total aggregate = 0.62
For pumpable concrete this value should be reduced by 10%
Therefore, volume of coarse aggregate= 0.62x0.9 = 0.558
Volume of fine aggregate content =1-0.558= 0.442

Step 6: Estimation of the mix ingredients
The mix calculations per unit volume of concrete shall be as follows

A. Volume of concrete =1m3
B. Volume of cement = (mass of cement/ specific gravity of cement) x1/1000 = (389.84/3.15)x1/1000 = 0.123 m3
C. Volume of water = (mass of water/specific gravity of water) x1/1000 = (194.92/1) x 1/1000 = 0.194 m3 d) Volume of all in aggregate =a- (b+c) =1- (0.123+0.194) = 0.683 m3
D. Mass of coarse aggregate = d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.683 x 0.558 x 2.56 x 1000 = 975.65 Kg
E. Mass of fine aggregate = d x volume of fine aggregate x specific gravity of fine aggregate x1000 = 0.683 x 2.70 x 0.442 x 1000 = 815.09 Kg

Step 7: Mix proportion for trial

A. Cement = 214.42Kg/m3
B. Fly ash = 136.44Kg/m3
C. Lime = 38.98Kg/m3
D. Fine aggregate = 815.09Kg/m3
E. Coarse aggregate = 975.65Kg/m3
F. Water Cement Ratio =0.50
G. Water = 194.92Kg/m

RESULT:-

1. COMPRESSIVE STRENGTH TEST RESULT

The experimental investigation was planned to know the effect of fly ash as a replacement to ordinary Portland cement (43 grade). Five types of concrete mixes were prepared using 150x150x150 mm mould for control concrete. M20 mix was designed as per IS10262:2009.

Table 1 Result at 0%percent replacement for compressive strength

Sample Name	7 days strength (N/mm2)	14 days strength (N/mm2)	28 days strength (N/mm2)
0% replacement	16.9	20.32	25.3

Table 2 Result of 7 days curing after replacement of cement

Replacement level	FA-L	FA-L	FA-L	FA-L
% of Replacement	20%-10%	25%-10%	30%-10%	35%-10%
Curing period 7 days	17.34 17.36 17.38	17.46 17.48 17.50	17.95 17.97 17.99	17.52 17.54 17.56

The graph here shows the compressive strength result of average cement: fly ash: cubes when cured in water for 7 days with respective replacement. It shows the strength of CE: FA: L is maximum at 30% and 10% replacement of cement by fly ash respectively.

Table 3 Result of 14 days curing after replacement of cement

Replacement level	FA-L	FA-L	FA-L	FA-L
% of Replacement	20%-10%	25%-10%	30%-10%	35%-10%
Curing period 14 days	20.40 20.42 20.43	20.42 20.44 20.46	20.46 20.48 20.50	20.44 20.46 20.44

The compressive strength result of average cement: fly ash: lime powder cubes when cured in water for 14 days with respective replacement. It shows the strength of CE: FA: L is maximum at 30% and 10% replacement of cement by fly ash and lime respectively.

Table 7.1.4 Result of 28 days curing after replacement of cement

Replacement level	FA-L			
% of Replacement	20%-10%	25%-10%	30%-10%	35%-10%
Curing period 28 days	25.41 25.43 25.45	25.47 25.48 25.49	25.63 25.65 25.67	25.52 25.54 25.56

The compressive strength result of average cement: fly ash: cubes when cured in water for 28 days with respective replacement. It shows the strength of CE: FA: is maximum at 30% and 10% replacement of cement by fly ash and lime respectively.

CONCLUSION

India has a vast resource of fly ash and lime generation all across the country. This material if segregated, collected and used properly can solve the major problem can solve the major problems of fly ash disposal and reducing the use of cement, which consumes lot of energy and natural resources.

Especially in India many organizations are putting their efforts to promote the awareness of fly ash in concrete and its advantages.

Nuclear Power Corporation of India Ltd (NPCIL) is also involved in R&D activities for development of fly ash concrete and implementing it in construction of nuclear power structure.

The experimental exercise has helped to study the various properties of fly ash concrete and to develop the mix design curves for concrete mix proportioning with various percentages of fly ash.

Based on the studies conducted by authors following conclusion are drawn on the fly ash concrete.

1. Use of fly ash and lime improves the workability of concrete. This phenomenon can be used either the unit water content of mix or to reduce the admixture dosage.
2. Density and air content of concrete mix are generally unaffected with the use of fly ash.
3. Normally use of fly ash slightly retards the setting time of concrete, but it is compensated by reduction in the admixture dosage to maintain the same workability.
4. Bleeding in fly ash concrete is significantly reduced and other properties like cohesiveness, pumping characteristics and surface finish are improved.
5. Rate of strength development at various ages is related to the W/Cm and percentages offly ash in the concrete mix.
6. Fly ash concrete is more durable as compare to OPC concrete. The time has come for appreciating the fact without any reservation that fly ash can be gain fully used in Making concrete strong, durable, Eco-friendly and economical.

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